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Original Article

Muscular strength and aerobic resistance: are there differences of physical performance during the stages of two menstrual cycles?

Força muscular e resistência aeróbia: existem diferenças de desempenho físico durante as fases de dois ciclos menstruais?

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ABSTRACT

Introduction: The menstrual cycle has been pointed as a possible factor of interference in the physical training, but the relation between its different phases and the physical performance has been recent target of investigation.

Aim: to verify the physical performance in the motor capacities of aerobic resistance and muscular strength during the menstrual cycle phases.

Methods: During two complete menstrual cycles, 12 healthy, active and oral contraceptive women underwent a training protocol. During training were evaluated for physical performance in each phase of each cycle through the tests: Yo Yo Test 1 and one repetition maximum test (1RM) for exercises in the leg extension, bench press, leg curl and rower machine.

Results: There was reduction of the resistance performance in the follicular phase for both menstrual cycles evaluated. The behavior of muscle strength was significantly higher in the second cycle for the bench press and leg curl exercises.

Conclusion: the performance on resistance capacity in active women, when evaluated in two menstrual cycles, is lower in the follicular phase, while the muscular strength performance was not influenced by the menstrual cycle phases.

Key-words: Physical fitness, Exercise, Women.

RESUMO

Introdução: O ciclo menstrual tem sido apontado como um possível fator de interferência no treinamento físico, porém a relação entre suas diferentes fases e o desempenho físico tem sido alvo recente de investigação.

Objetivo: verificar o desempenho físico nas capacidades biomotoras de resistência aeróbia e força muscular durante as fases do ciclo menstrual.

Métodos: Durante dois ciclos menstruais, 12 mulheres saudáveis, ativas e usuárias de contraceptivos orais foram submetidas a um protocolo de treinamento e foram avaliadas quanto ao desempenho físico em cada fase de cada ciclo menstrual por meio dos testes: Yo Yo Test 1 e teste de uma repetição máxima (1RM) para os exercícios: cadeira extensora, supino reto, cadeira flexora e remada.

Resultados: Houve redução do desempenho no teste de resistência na fase folicular para ambos os ciclos menstruais avaliados. Já o comportamento da força muscular apresentou-se significativamente maior ($p<0,05$) no segundo ciclo para os exercícios supino reto e cadeira flexora.

Conclusão: o desempenho na capacidade de resistência em mulheres ativas, quando avaliado em dois ciclos menstruais, é menor na fase folicular, e que o desempenho de força muscular não foi influenciado pelas fases do ciclo menstrual.

Palavras-chave: Aptidão física, Exercício, Mulheres.

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Introduction

In recent years, the possible influence of the menstrual cycle (MC) on physical performance (PP) has been a concern for athletes, health professionals and researchers. Hormonal fluctuations, common during this process, produce physiological responses according to MC phases and can lead to changes in the performance of physical exercises [1]. The MC is the result of events coordinated by the hypothalamic-pituitary-ovarian axis and it is divided into the phases: Follicular, Ovulatory and Luteal. During the follicular phase, blood concentrations of estrogen and progesterone are low and in the luteal phase they are high, in the ovulatory phase the concentration of estrogen is high and progesterone is low. Hormonal fluctuations cause bodily responses such as psychological, renal, body weight, substrate metabolism changes, and they affect the cardiovascular system, bones, brain, thermoregulation and ventilation [1,2].

Despite the possible physiological changes regarding physical exercise, Lebrun [1] found no significant differences in the literature regarding aerobic, anaerobic or muscle strength capacity between MC phases. On the other hand, studies suggest that the hormonal variation of this period favors PP in exercises during the ovulatory phase and leads to a lower DF during the luteal phase, one of the justifications being the catabolic aspect of progesterone and anabolic estrogen [3-5]. Studies that assess PP in aerobic resistance argue that hormonal fluctuations during the MC do not significantly affect PP [1,6-8]. However, there are reports that during the luteal phase there is a reduction in the PP [9] or an improvement in the recovery of oxygen consumption [10].

As for muscle strength, Thompson [11] suggests that hormonal changes in MC may influence PP, since estrogen and progesterone receptors are identified in skeletal muscles. Greater muscle strength performance is documented during the luteal phase of the MC by Loureiro [12] and during the follicular phase by Wikström-Frisén [13]. On the other hand, there are reports of decreased muscle strength during the follicular phase [11,14,15], and studies that found no significant differences in muscle strength performance between MC phases [6,12,15-20].

The divergences found regarding the PP in the different MC phases may be related to the methodological differences between the studies. In addition, most studies evaluate PP during just one MC, limiting the understanding of the phases of this cycle in extended periods. Therefore, studies that approach the MC as a periodic process regarding multiple cycles are relevant to demonstrate potential fluctuations in PP in biomotor capacities between cycles. Thus, this study investigated the influence of MC phases on the performance of motor skills: aerobic resistance and muscular strength of lower limbs and upper limbs, in a period of two menstrual cycles.

Methods

This is a prospective cross-sectional study, approved by the Research Ethics Committee of the State University of Campinas (CEP - UNICAMP) under approval number 2,678,716, CAAE: 87128617.2.0000.5404.

Sample

Twelve healthy university women participated in this study, with an average age of 26 ± 3.7 years and physically active, practicing dance. In addition, they had been using oral contraceptives (of various brands) for at least six months, 21-day ingestion pattern and a 7-day break, or 24-day ingestion pattern and a 4-day break, or continuous daily intake.

The level of physical activity was determined via simple self-report on the practice of weekly physical activities and the following inclusion criteria were considered through self-report: making use of oral contraceptives with the purpose of regulating and manipulating the MC [21], as well as being physically active (exercising at least twice a week). The following exclusion criteria were considered: having a cardiovascular, neuromuscular disease or pathology under treatment.

After selecting the volunteers, the participants were informed about the research and were only included in the project after reading and signing the Free and Informed Consent Form.

Experimental protocol

During two weeks prior to the data collection, a familiarization was made including the performance tests and exercises proposed for training, a weekly meeting being conducted for each and following the data collection protocols likewise. In addition, the current MC phase the volunteers were in was determined.

Over the course of eight weeks completing a period of two consecutive MCs, in two weekly 60-minute meetings, the volunteers underwent motor skills training (aerobic endurance and muscle strength) and were evaluated in performance tests at the end of each MC phase. Therefore, the performance test included a third weekly meeting for the weeks when the MC phase changed.

During this period, the volunteers did only the exercises proposed by the project, avoiding the influence of other physical practices on the performance results. All meetings took place in the morning, maintaining the same schedule per volunteer. The order of data collection procedures for capacity training and performance tests are shown in Figures 1A and 1B.

Biomotor skills training: For resistance training, continuous running in open space was prescribed. Then, for strength, large muscle group exercises were prescribed, with an interval of one minute between sets and between exercises. In addition, the load used was based on the maximum repetition percentage (1RM) of the last test done by the volunteer. The first time, the load was estimated based on the last test performed during familiarization (Figure 1A).

Physical performance tests (Figure 1B): The first day of tests occurred in the follicular phase, between the third and the fifth day of the MC (in the first cycle called follicular phase 1 (FOL1) and in the second cycle follicular phase 2 (FOL2). The second day of tests, on the other hand, occurred during the ovulatory phase, between the ninth and the 10th day of the MC, (OVU1 and OVU2 respectively). Lastly, the third day of testing took place during the luteal phase, between the 17th and the 21st day of the MC (LUT1 and LUT2) [12]. During the performance tests, the volunteers did not make any other intense physical effort.

For verifying resilience capacity, the Yo-Yo Intermittent Recovery Test - Level 1 [22] was applied to evaluate the displacement capacity (in meters) at high intensity repeatedly. This test consists of two courses of 20 meters each (round trip) in a variation of increasing difficulty. Displacements are announced by a beep and have a 10-second recovery interval between them. The volunteers carried out as many rou-

nds and turns as they could. The test ended when the participant did not reach the 20 meter mark twice in a row within the requested time, indicating physical wear and tear.

The one repetition maximum test (1RM) was used to assess muscle strength capacity [23]. Before its execution, eight repetitions were warmed up with 50% of the 1RM load presented in the previous test, followed by three repetitions at 70% of 1RM. For the first test, the heating load was stipulated so that the participant could complete the series with ease. The 1RM test measured the maximum load at which a single repetition could be performed with the correct technique, it was not possible to perform a second repetition and for each attempt an interval of five minutes was maintained.

The PP tests were performed in the same order as the training, but respecting the minimum pause necessary for the volunteer's recovery, decreasing the influence of one capacity over the other: after the Yo Test 1 there was an interval of 10 minutes before the 1RM tests. However, there is still an influence of one capacity over the other in carrying out the tests on the same day, since the energy reserve for performing the 1RM test is lower after the Yo Test 1.

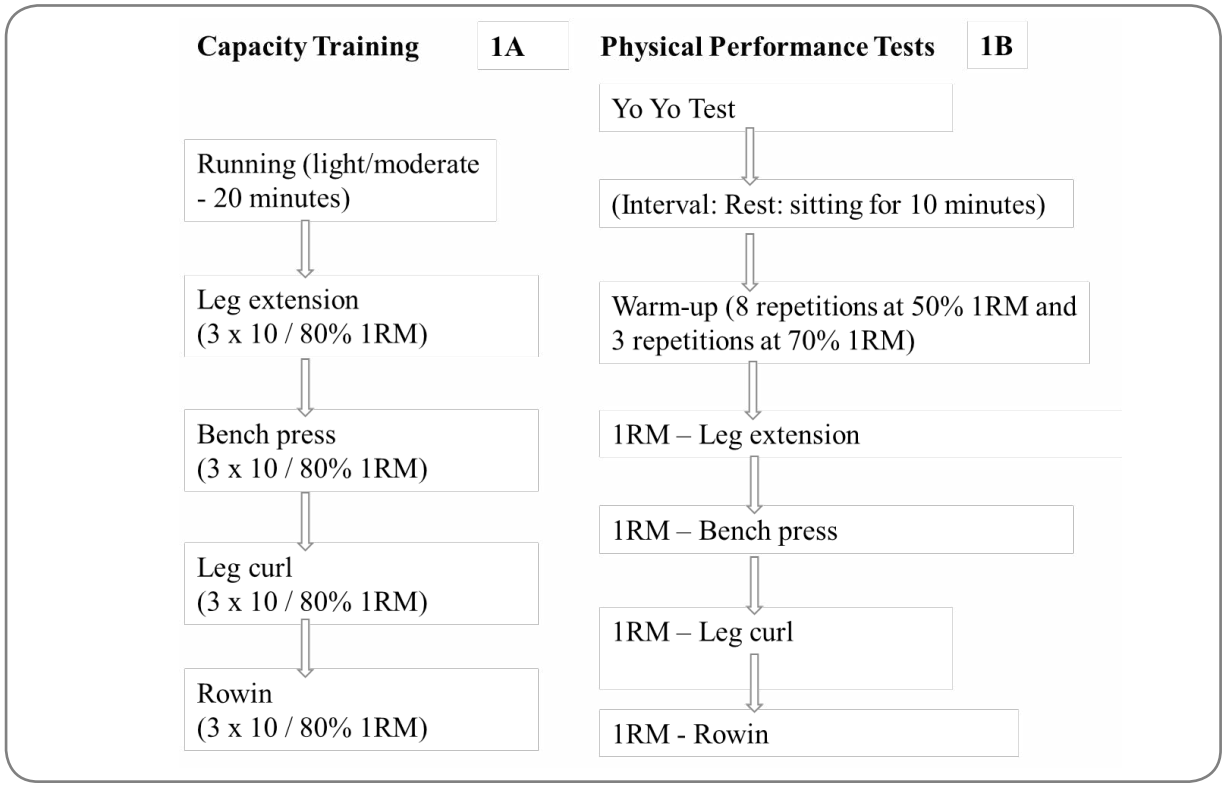


Figure 1 - Description of the order of data collection procedures. 1A: Description of the skills training protocol. 1B: Description of the physical performance testing protocol.

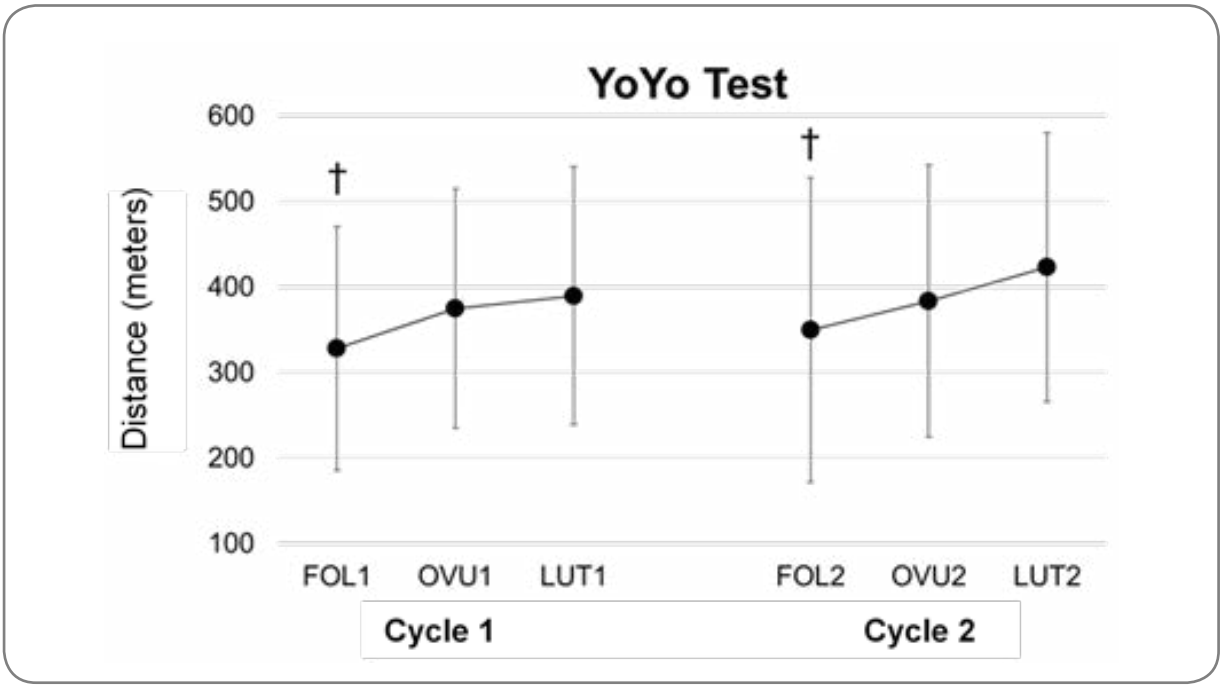
Statistical analysis

The dependent variables of the present study are: YoYo-Test execution time, and maximum strength (1RM) in the leg extension, bench press, leg curl and rowing exercises. All variables will be presented as mean ±1 standard deviation. The normality of the dependent variables was verified by the Shapiro-Wilk test. To verify the effects of the menstrual cycle (Cycle 1 vs Cycle 2) and the MC phase (FOL vs OVU vs LUT), 2-way ANOVA was used for repeated measurements with use of SPSS (Version 24, SPSS, Inc., Chicago, IL, USA). In the case of the significant effect of the MC phase, Bonferroni tests were used for post-hoc analysis. The level of significance was set at

$p < 0.05$, and the values of F and effect size (partial ETA square) were reported for the 2-way ANOVA in case of significant effects.

Results

A significant effect was found for the phases of the MC in the distance covered during the Yo Test 1 ($F(2.10) = 7.159$, effect-size = 0.394, $p<0.05$, Figure 2). The post-hoc analysis showed that the distance covered is shorter during the FOL phase compared to the OVU ($p<0.05$) and LUT ($p<0.05$) phases. There was no significant effect of MC, nor interaction between MC vs cycle phase for this variable.



† denotes a significant difference in relation to the ovulatory and luteal phase ($p<0.05$).
Figure 2 - Mean (SD) of the distance covered during the Yo Yo Test 1 in MCs 1 and 2, subdivided into the follicular (FOL1 and FOL2), ovulatory (OVU1 and OVU2) and luteal (LUT1 and LUT2) phases.

There was a significant effect of MC on the maximum bench press load ($F(1.11) = 24.497$, effect-size = 0.690, $p<0.0001$, Figure 3B), and leg curl ($F(1.11) = 9.158$, effect-size = 0.454, p 0.05, Figure 3C). For both variables, the maximum load was higher in the second MC compared to the first. There was no effect of the MC phase for the extensor chair exercises ($p = 0.08$ [Figure 3A], considered a trend), and rowing ($p = 0.727$, Figure 3D). There was no significant effect of the MC phase, as well as interaction between MC vs cycle phase for any muscle strength variable.

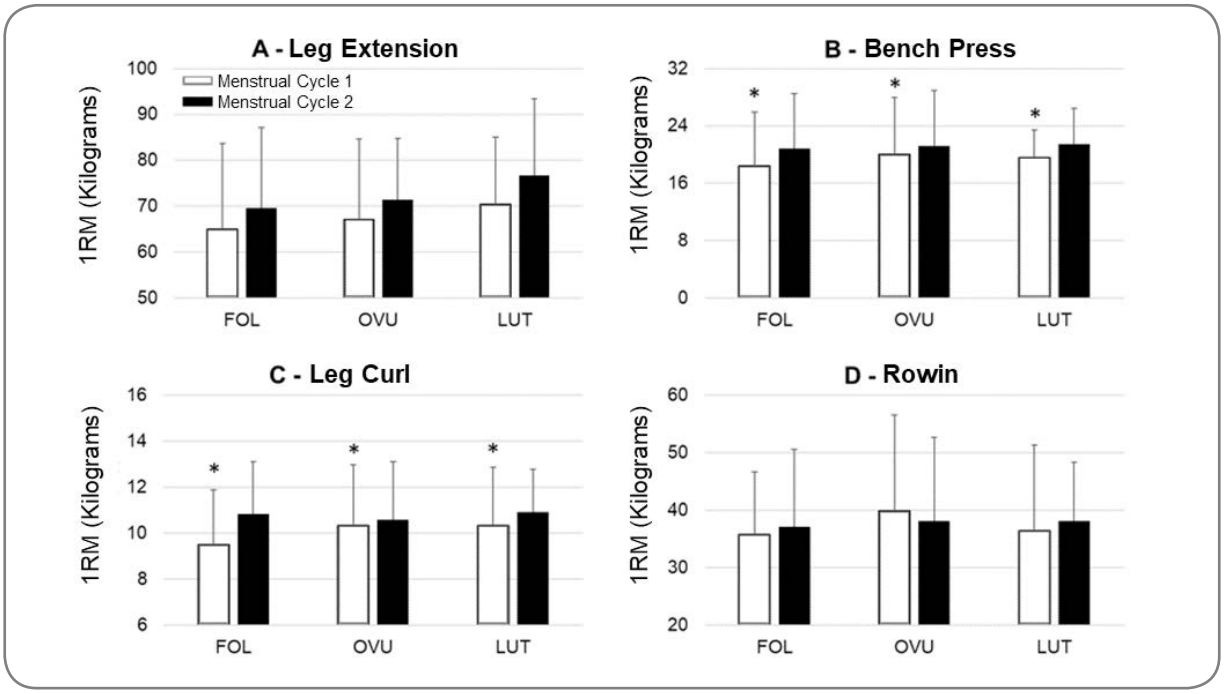


Figure 3 - Mean (SD) of the one maximum repetition (1RM) during the leg extension (A), bench press (B), leg curl (C) and rowing (D) exercises during MC 1 (gray bars) and MC 2 (black bars), subdivided into follicular (FOL), ovular (OVU) and luteal (LUT). * denotes a significant difference in relation to CM 2 ($p<0.05$). .

Discussion

This study stands out for evaluating a period longer than a MC, simultaneously evaluating more than one biomotor capacity and having a training protocol during the analysis period. Regarding the resistance capacity, the results presented show a lower performance in the follicular phase than in the ovulatory and luteal phases in both evaluated MCs. In addition, there were no significant differences in resistance performance between cycles, likely due to the applied training, which did not lead to sufficient adaptations to generate differences in performance between one cycle and another.

The lower performance in the follicular phase compared to the other phases found in both cycles can be justified because it was evaluated at the beginning of the follicular phase. During this period, women's menstruation occurs, which can lead to natural discomfort due to blood flow and swelling, generating less disposition to physical activity [24]. Blood estrogen concentrations are low, and this being a hormone associated with the production of serotonin, a neurotransmitter that regulates mood, appetite, sleep and other physiological variables, the mood and motivation to do physical exercises may decrease, in addition to the possibility of presenting menstrual cramps that also influence the practice of physical activities [24,25].

Some studies that evaluate only one CM are contrary to our findings. Julian et al. [9] investigated the resistance performance in the different MC phases using the Yo-Yo Intermittent endurance test (Yo-Yo IET) and found less performance in the luteal phase compared to the follicular phase. In the same direction Silva et al. [6], using the Yo-Yo Test 1, found no performance differences between MC phases. Both studies are similar in terms of the evaluation method, but they differ from our study in terms of analyzed population, namely soccer athletes (n = 9) and women trained in resistance exercises (n = 11), respectively. Similar results were found by studies that

use other methods of assessing resistance capacity and that evaluate women with different levels of training [17,8].

Regarding physically active women, Middleton [10] suggests better recovery of VO2 during the luteal phase, however it differs in its research objectives, as well as in the methods of evaluating the performance and division of the MC phases. Our results make the relationship between MC and aerobic resistance performance in physically active women clearer, as it evaluates this population that has not yet been investigated, and because it is a pioneering study in the evaluation of resistance performance in two MCs.

Differently from what was observed in the endurance performance results, the data obtained on the muscular strength capacity indicate a significant performance improvement in the second cycle for the bench press and leg curl exercises, which was not observed for the extension and row chair. The improvement in strength performance in the exercises from one MC to the other can be justified by the neural adaptation to training and strength gain, according to the training protocol adopted [4]. If a period longer than two cycles were adopted, we would likely report an increase in performance also for the rowing and leg extension exercises (which showed an increasing trend).

In addition, our results showed no significant differences in performance in all strength exercises between MC phases, similarly to studies that evaluate a single MC and women trained in resistance exercises via the load test [18], and physically active women [16] trained in aerobic exercises [17], as well as athletes [20] using the isokinetic dynamometer. These findings, together with our results, indicate that MC phases do not influence the strength performance assessed by different methods and in women of different levels of physical fitness.

On the other hand, studies indicate a decrease in the strength performance of physically active women [11,15] and women trained in resistance exercises [14] during the follicular phase. However, they use other methods of strength assessment such as isometric strength assessment, 8RM test and total volume of load used, respectively. The divergence of results between these studies can be justified by the methodological differences presented. It is also noteworthy that the afore mentioned studies evaluate only one MC.

Like the present study, Fridén [19] investigated the strength performance of physically active women (n=10) during two MCs. However, handgrip strength and isokinetic muscle strength tests in the leg extension machine were used, a specific training protocol was not applied during the period analyzed, and the volunteers did not use oral contraceptives. As a result, no significant differences were found between MC phases for any variable in both evaluated MCs, similarly to our findings. Thus, physically active women, when evaluated by two MCs, regardless of the method used to assess muscle strength, of oral contraceptives are used, and presence of training protocol, are suggested to have no influence of MC phases under strength performance.

We point out as limitations of this study the lack of control over the intensity of resistance training, which interfered in the progress of physical performance for this biomotor capacity, in addition to the low number of participants. New studies are suggested to verify how the evaluation by different methods could influence the results of strength performance.

Conclusion

This study demonstrated that physically active women show distinct changes in aerobic endurance and muscle strength when two menstrual cycles (and their phases) are compared. The performance of aerobic resistance was lower in the follicular phase in both evaluated cycles, while muscular strength did not change significantly between different phases of the menstrual cycle. In addition, when comparing one menstrual cycle and another, there is a significant increase in strength performance, but not in aerobic endurance performance.

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Conflicts of Interest
No conflicts of interest with potential potential for this article have been reported.

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Authors' Contribution
Conception and design of the research: Borin JP, Ribeiro IC. **Data collection:** Ribeiro IC, Carvalho LHF. **Analysis and interpretation of data:** Ribeiro IC, Oliveira ASC, Borin JP. **Statistical analysis:** Oliveira ASC, Padovani CR. **Obtaining financing:** Not applicable. **Writing of the manuscript:** Ribeiro IC, Carvalho LHF, Oliveira ASC, Borin JP. **Critical review of the manuscript for important intellectual content:** Ribeiro IC, Borin JP.

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